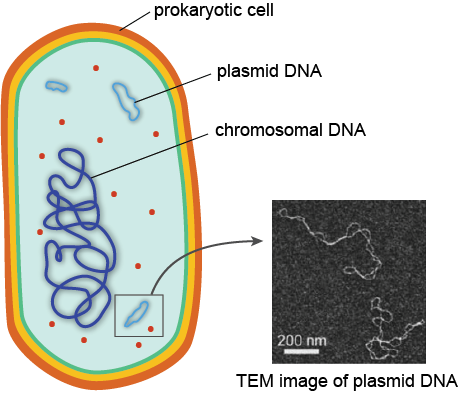
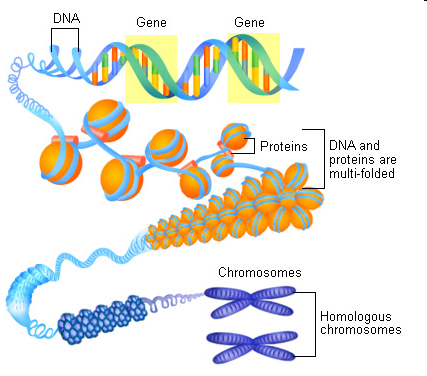
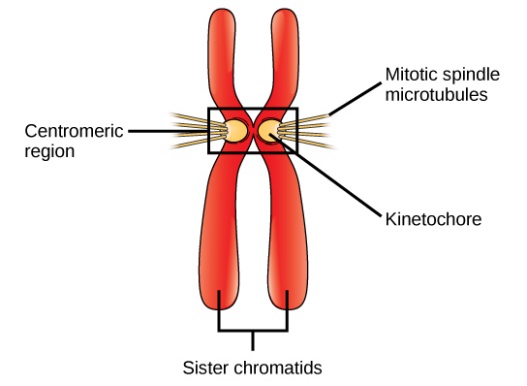
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**Unit 8 Notes, Part 1: The Cell Cycle and Mitosis**

Mrs. Krouse, AP Biology

**Organization of Genetic Material**

1. The cell’s total library of DNA is called its genome.
2. The prokaryotic genome is typically a single, long DNA molecule. In prokaryotic cells, there are also small circles of DNA called plasmids that are separate from the main genome.
3. A eukaryotic genome is much larger than a prokaryotic genome. For example, a human cell generally contains much more DNA than a bacterial cell.
4. The DNA in a cell must replicate (copy) before the cell divides for reproduction, growth, tissue repair, etc. so that each daughter cell has a copy of the parent cell’s genetic information.
5. In a human cell that is not actively dividing, DNA is typically found as chromatin, a loosely-structured complex of DNA and associated protein molecules called histones.
6. In a human cell that is preparing for division or actively dividing, DNA is found as chromosomes, which are strings of chromatin that are super-coiled. Chromatin coils up into chromosomes during cell division so that the X-shaped chromosomes can be easily split apart, and one half of each chromosome can be sent to each daughter cell.

7) Each side of an X-shaped chromosome is made of an identical copy of DNA called a sister chromatid. During cell division, these copies must be divided to give each daughter cell a full genome (aka genetic library). The chromosomes are connected at a region called the centromere. The proteins in the centromere that are attachment sites for mitotic spindle fibers (chromatid-separating structure used during cell division) are called kinetochores.

8) Humans and many other organisms have two types of cells—somatic cells and gametes. Somatic cells are normal body cells (ex: blood cells, bone cells, skin cells) that have two sets of chromosomes (one set from each parent). Human somatic cells have 46 chromosomes, or 23 chromosomes from each parent. Somatic cells are considered “diploid,” because they have two sets of chromosomes (Hint: “di” means two!).

Gametes are sex cells (eggs and sperm) that have one set of chromosomes. Gametes have one set of chromosomes (23 in humans) so that an egg can meet with a sperm during fertilization to create a fertilized egg (aka zygote) with two sets of chromosomes (46 chromosomes). This fertilized egg will divide many times to create a multicellular baby with 46 chromosomes in each of its cells. Gametes are considered “haploid” because they have one set of chromosomes (Hint: Associate “haploid” with “half” the chromosomes of a normal somatic cell!)

**The Cell Cycle**

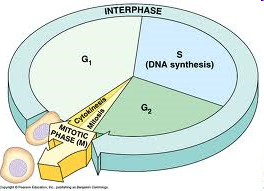
9) The ability to reproduce is one characteristic of living things.

10) Cell division can be used for purposes other than reproduction in some organisms. See the next page for a list of the functions of cell division in unicellular vs. multicellular organisms.

|  |  |
| --- | --- |
| **Unicellular Organisms** | **Multicellular Organisms** |
| * Reproduction only | * Replacing cells that die from normal wear and tear or from injury * Growth and development from a single fertilized egg (zygote) * Reproduce asexually (ex: plants can grow by “grafting” / “cutting”) |

11) Steps of the cell cycle (all the events in the life of a cell)

* Interphase comprises 90% of the cell cycle. In this portion of the cell cycle, the cell is not dividing and is going through all its normal activities. During this phase, the DNA is spread out as chromatin, and the nuclear membrane and nucleolus are visible. Interphase is divided into three phases (and sometimes a fourth). These phases are described below.

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**G1 phase** (first gap): the cell grows by producing proteins and organelles. (Note: this is the normal life of the cell!)

**S phase** (synthesis): the cell makes a copy of its DNA

**G2 phase** (second gap): the cell makes molecules / organelles needed for cell division

Ex: centrosomes are copied (these centrosomes contain centrioles in animal cells)

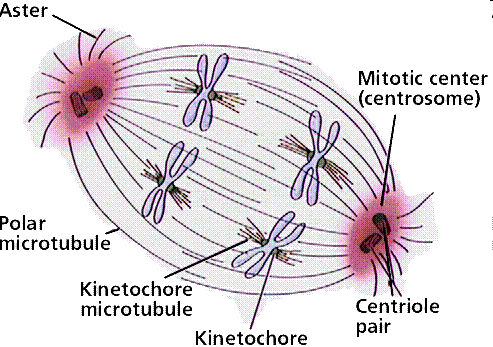
**G0 phase:** certain types of cells may leave the normal cell cycle and stop dividing

Ex: liver cells (can reenter the cell cycle if the liver is injured and damaged cells must be replaced); muscle / nerve cells (never divide again once they are mature)

* Interphase is followed by mitosis, the division of a cell’s nucleus, and cytokinesis, the division of a cell’s cytoplasm. At the end of the cell cycle, two daughter cells are produced that then enter the cell cycle again.
* A typical human cell divides around every 24 hours but certain types of cells (ex: skin cells) divide more frequently than others (ex: muscle cells). For the average 24 hour cell cycle, see how long the cell spends in each stage of the cycle below;

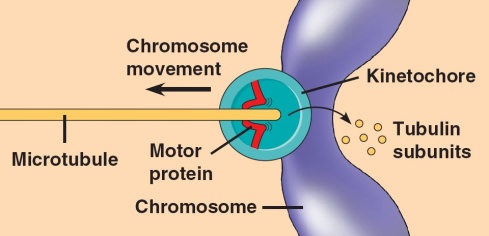
**M phase** **(mitosis)** < 1 hour

**S phase** = 10-12 hours

**G1 and G2 phase** = the rest of the time (G1 length varies the most between different cell types… ex: skin cells have shorter cell cycles and a shorter G1 phase than muscle cells)

**Cellular Equipment Needed for Division**

* The mitotic spindle is a structure that forms in the cytoplasm during the beginning stage of mitosis (prophase); it is used to separate sister chromatids during mitosis
* The spindle is assembled from elements of the cytoskeleton called microtubules (made of chains of tubulin proteins). The spindle fibers elongate by adding more tubulin subunits.
* Assembly of microtubule fibers starts in the centrosome, AKA the “microtubule organizing center.” In animal cells, organelles called centrioles are found at the center of the centrosome, but they do not seem to be necessary for spindle formation.
* Possible mechanisms for how the mitotic spindle works:

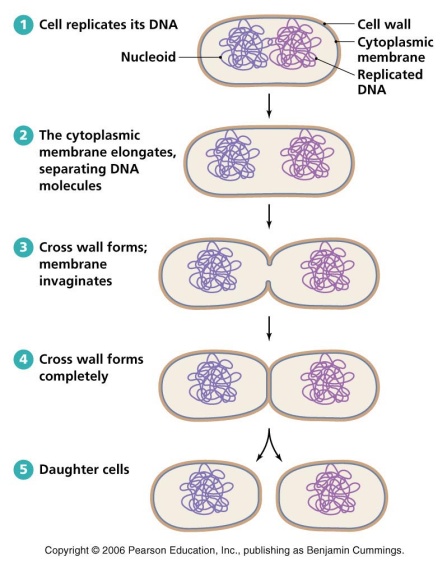
1. Chromosomes are “reeled in” by the shortening of microtubules at the poles (i.e. ends) of the dividing cell.

OR

1. Evidence suggests that microtubules may shorten at the end holding the chromosome as motor proteins on the kinetochore “walk” chromosomes along microtubules toward the poles / ends of the cell (see image to the right)

**The Stages of Mitosis**

|  |  |  |
| --- | --- | --- |
| **Stage Name** | **Description** | **Picture** |
| Prophase | * Chromatin becomes tightly coiled into chromosomes * The nucleolus disappears * Mitotic spindle begins to form as microtubules extend from the centrosomes. As microtubules “poke out” of the centrosome, it creates a structure that looks like a star or “aster.” * Centrosomes move toward the poles / ends of the dividing cell. |  |
| Prometaphase | * The nuclear membrane (aka the nuclear envelope) fragments (breaks apart) * Spindle fibers attach to chromosomes at their centromeres using kinetochore proteins * Some spindle fibers do not attach to chromosomes. These are called nonkinetochore fibers or nonkinetochore microtubules. | http://www.edupic.net/Images/Mitosis/prometaphase.png |
| Metaphase | * Longest dividing phase * Spindle fibers push chromosomes to line up along an imaginary plane at the equator (center of the cell) called the metaphase plate. |  |
| Anaphase | * Shortest dividing phase * Sister chromatids separate and move to opposite poles of the cell. Once the chromatids separate, each chromatid is considered a daughter chromosome. |  |
| Telophase | * AKA “reverse prophase” because the events that happen during prophase to prepare the cell for mitosis occur in reverse during telophase to end mitosis * Two daughter nucleoli begin to reform * Nuclear envelopes reform * Chromosomes uncoil into chromatin * Mitotic spindle fibers break down |  |
| Cytokinesis | * Cytoplasm splits * Usually starts in late telophase * The cleavage furrow splits animal cells (actin and myosin proteins interact to contract a ring around the membrane) **(see note on actin and myosin proteins below!)** * The cell plate splits plant cells (cell wall materials are deposited between the two daughter cells by vesicles from the Golgi) |  |

**Evolution of Mitosis**

* Mitosis may have had its origins in binary fission, a method used by bacteria to reproduce
* In binary fission…

1. Bacteria have a large circular chromosome
2. Replication of DNA (before division) starts at one point on the chromosome called the origin of replication and moves in both directions
3. The cell elongates
4. The plasma membrane (aka cell membrane) pinches inward as a new cell wall (called a cross wall in the image to the right) forms between the daughter cells
5. The cell is divided into two daughter cells, each with a complete genome
6. No spindle or microtubules are involved in this process, but several proteins play a role in this process (you do not need to know their names, but know that they are related to tubulin and actin—two cytoskeleton proteins—and they are similar to eukaryotic proteins…hence the connection between binary fission and mitosis!)

***\*\*\*Note on actin and myosin proteins used in the formation of a cleavage furrow during animal cell cytokinesis:*** *Actin and myosin are two proteins that are also used in muscle cell contraction in humans. Myosin has small “heads” that can attach to actin and pull it, just like human hands pull a rope in a tug-of-war competition. This causes the muscle cell to shorten and contract. The interaction between actin and myosin also causes the plasma membrane at the center of a dividing cell to contract / pinch, forming the cleavage furrow.*

